LANSCE at a Glance

LANSCE at a Glance

The Los Alamos Neutron Science Center (LANSCE) accelerator complex presents an extraordinary opportunity for U.S. science and technology. LANSCE is the highest-power proton linear accelerator (linac) in the world and provides the world's highest (peak) neutron fluxes spanning nearly 16 orders of magnitude in neutron energy.

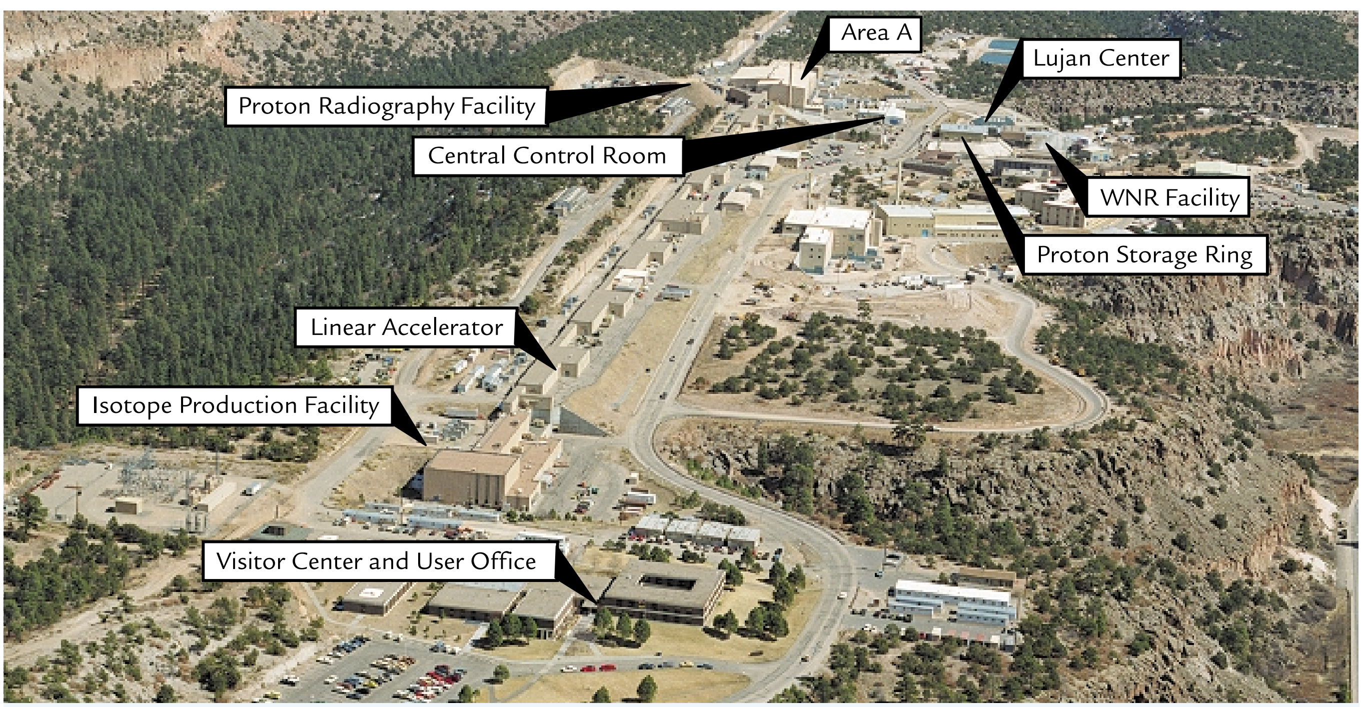
Three major Department of Energy (DOE) stakeholders—Defense Programs (DP); Office of Science (SC); and Office of Nuclear Energy, Science, and Technology (NE)—have recently invested in the LANSCE complex to provide essential infrastructure upgrades and new scientific capabilities and to enhance the U.S. radioisotope production capability. LANSCE's major experimental capabilities are (1) a dedicated facility for proton radiography (PRAD) at 800 MeV; (2) the Manuel Lujan Jr. Neutron Scattering Center (Lujan Center), which has a moderated neutron source (meV to eV) primarily for neutron-scattering research; and (3) the Weapons Neutron Research (WNR) Facility, which has an unmoderated neutron source (keV to 800 MeV) for research in nuclear science and technology, as well as for the irradiation testing of industrial components such as computer chips.

In addition to these existing facilities, the Chemistry Division and LANSCE are constructing an NE-funded Isotope Production Facility (IPF) to satisfy a national need for biomedical radioisotopes. The ability to produce the most intense source of ultra-cold neutrons (UCNs) in the world has been demonstrated at LANSCE, and there are plans to establish a dedicated UCN facility. In addition, a proposed Advanced Hydrotest Facility (AHF) could provide a unique capability for three-dimensional studies of fast dynamic events. This AHF would consist of a 50-GeV proton synchrotron constructed in a tunnel 350 ft below the LANSCE linac and an array of transport lines to supply proton pulses to illuminate a dynamic test object. A set of large-aperture magnetic lenses will image the protons passing through the test object at many times, creating a radiographic "movie."

These capabilities provide the National Nuclear Security Administration (NNSA), DOE/SC, DOE/NE, and Los Alamos National Laboratory (LANL) with powerful applied, basic, defense, and industrial research capabilities.

A National User Facility

As a national user facility for defense and civilian research in radiography, nuclear science, and condensed-matter science, LANSCE hosts scientists from universities, industry, the Laboratory, and other research facilities from around the world. Scientists apply for beam time by completing a proposal, which is subjected to appropriate peer review before beam



↑ *The Los Alamos Neutron Science Center.*

time is granted. Once beam time is granted, the experiment is reviewed for technical and safety issues. Information about LANSCE and a blank proposal form are available at *http://lansce.lanl.gov*.

Experimenters who use the facility are also encouraged to join the LANSCE User Group, which enables them to influence operating policies, future instrumentation, and other factors that impact users. Additional information about the LANSCE User Group is available in the User Program section of this report.

Financial support for the operation of LANSCE is provided by the DOE/DP and by the DOE Office of Basic Energy Sciences (OBES). These two offices have long-term, synergistic needs for research using the neutrons that LANSCE provides.

Particle Beam Production

High-Intensity Proton Linear Accelerator

LANSCE is the world's most versatile spallation neutron source. Its high-intensity, 1-MW proton linac is the heart of many LANSCE activities. A hydrogen atom contains only one electron orbiting a nucleus with a single proton. When that electron is stripped off, a positive hydrogen ion (H^+), or proton, remains. Adding a second electron to a hydrogen atom produces a negative ion (H^-). The LANSCE high-intensity proton linac can simultaneously produce and accelerate H^+ and H^- ions to energies of 800 MeV. The three-stage, half-mile-long linac is capable of providing H^+ beam with an average current of up to 1 mA at a repetition rate of 100 Hz and a peak current of 17 mA. The H^- beam produced by the linac has an average current of up to 100 μA at a repetition rate of 20 Hz and a peak current of 20 mA at Lujan Center and up to 5 μA at 100 Hz at WNR.

The first stage of the accelerator contains injector systems for each kind of particle (H^+ and H^-). Each injector system has a 750-keV Cockroft-Walton generator and an ion source. The two ion sources produce H^+ and H^- particles inside high-voltage domes. When the particles leave the injectors, they achieve velocities at 4% of the speed of light. The two ion beams are merged, bunched, and matched into a 201.25-MHz drift-tube linac for further acceleration to 100 MeV (43% of the speed of light). The third and longest stage of the accelerator (800 m) is the side-coupled-cavity linac, where particles are accelerated to their final energy of 800 MeV (84% of the speed of light).

The particle beams from the linac are separated and directed down three main beam lines leading to several experimental areas, including the PRAD facility, the Lujan Center, and the WNR Facility. Operators can control the H^+ and H^- beams separately, allowing most experiments to run simultaneously.

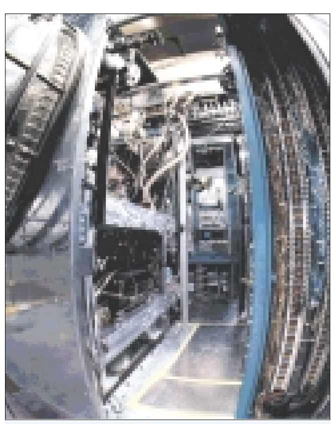
Proton Storage Ring

The Proton Storage Ring (PSR) converts H^- linac macropulses that are approximately 750 ms long into short (0.13 μs full-width at half-maximum), intense H^+ bursts that provide the capability for precise neutron time-of-flight (TOF) measurements for a variety of experimental programs. The PSR-compressed macropulses are sent to the Lujan Center neutron production target 20 times a second.

Neutron Production

The nuclear reaction process that occurs when protons strike heavy-metal targets, such as tungsten, is known as spallation. This process is used to produce neutrons from the nuclei of the target atoms. For the 800-MeV proton beams used at LANSCE, about 20 neutrons per

↑ *Cockroft-Walton injector.*



↑ *Inside Cockroft-Walton injector.*

↑ *The LANSCE linear accelerator.*

proton are ejected. The short, highly intense bursts of spallation neutrons are used in neutron-scattering and nuclear-science experiments. The neutrons produced have energies up to several hundred million electron volts, which are the right energies for nuclear-physics experiments at WNR and some experiments at the Lujan Center.

Moderators

For the majority of the neutron-scattering research being done at the Lujan Center, the initial spallation neutron energies are too high, and correspondingly, their wavelengths are too short, for investigating condensed matter. For this reason, the neutrons must be "cooled down" before being used for scattering experiments. This process is accomplished by allowing the neutrons to interact with a moderator—a material with a large scattering cross section such as water or liquid hydrogen. Neutrons enter the moderator (which is placed close to the neutron source), and in a series of collisions, lose energy to moderator atoms. After a few tens of collisions, the neutron energies are similar to the thermal energy of the moderator. Thus neutrons are emitted from the moderator with an average energy determined by the moderator temperature. The average energy of the neutrons from a water moderator is approximately 25 meV, whereas the average energy from the liquid hydrogen moderator at 20 K is approximately 5 meV. The energies and wavelengths (around 1.8 Å for 25 meV) of these neutrons match the excitation energies and interatomic spacings of matter and are thus very useful for neutron-scattering experiments that probe material structure.

Experimental Facilities

Manuel Lujan Jr. Neutron Scattering Center

Researchers from universities, industry, Los Alamos, and other research facilities use the moderated spallation neutrons at the Lujan Center for materials science and engineering, condensed-matter physics, polymer science, chemistry, earth sciences, structural biology, and nuclear-science research. A unique split-target design and flux-trap moderators yield a higher peak neutron flux at the Lujan Center than any other spallation neutron source.

Instruments and Flight Paths

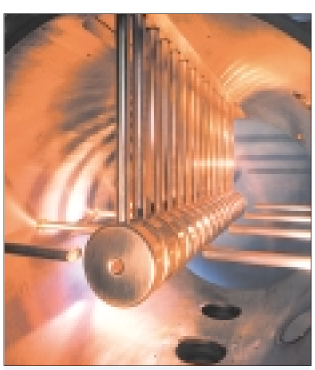
Most of the flight paths (FPs) at the Lujan Center are equipped with spectrometers for determining the atomic, molecular, and magnetic structures as well as the vibrational and magnetic excitations of materials. Of the sixteen FPs, ten have instruments for condensed-matter science and engineering, two are used for nuclear-science research, and three are being instrumented.

Weapons Neutron Research Facility

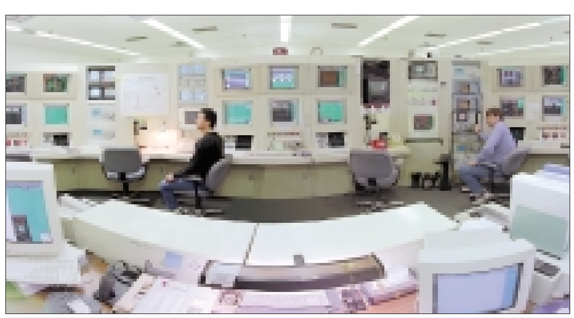
At the WNR Facility, high-energy, unmoderated neutrons and protons are used for basic and applied research in nuclear-science and weapons-related measurements. The WNR Facility consists of two target areas: Target 2 and Target 4 and their associated FPs. The neutron beams produced at WNR complement those produced at the Lujan Center because the beams at WNR are of much higher energy and have shorter pulse duration. With both capabilities, LANSCE is able to deliver neutrons with energies ranging from small fractions of an electron volt to 800 MeV. During the 1999-2000 run cycle, WNR operated continuously at the highest proton current ever achieved for this facility.

Instruments and Flight Paths

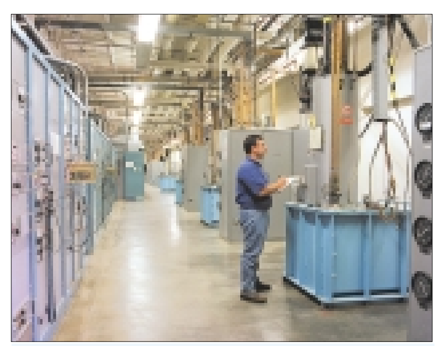
At Target 2, also known as the Blue Room, proton-induced reactions can be studied using the linac or the PSR proton beam. In addition, the Blue Room is used for a variety of proton-irradiation experiments. This target consists of a low-background room with seven FPs (one is unused). Experiments in the Blue Room can exploit the variable-energy feature of the linac using proton beams from 250 to 800 MeV.



↑ *Drift tubes inside linac.*

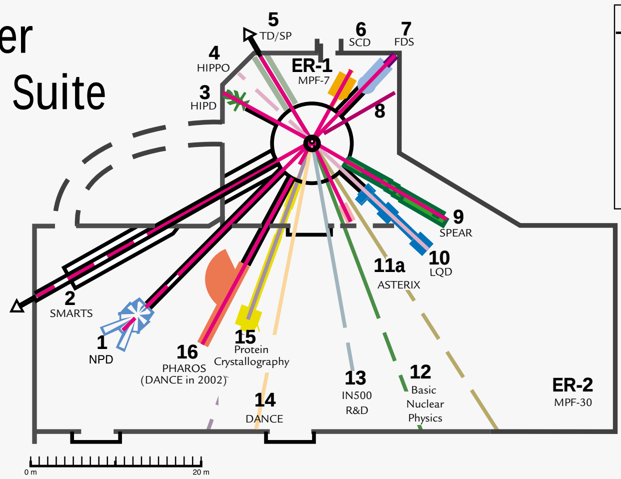


↑ *Accelerator control room.*



↑ *The klystron gallery.*

Lujan Center Instrument Suite



Moderators
1, 2, 16: high-resolution H_2O decoupled
3, 4, 5: high-intensity H_2O decoupled
6, 7, 8: high-intensity H_2O decoupled
9, 10, 11: ℓH_2 @ 20 K partially coupled
12, 13: ℓH_2 @ 20 K coupled
14, 15: H_2O coupled

FP1 **Neutron Powder Diffractometer (NPD)** allows for studies of complex structures, internal strain measurements, and phase transformation.
Don Brown, 505-667-7904, dbrown@lanl.gov

FP2 **Spectrometer for Materials Research at Temperature and Stress (SMARTS)** will allow measurements of spatially resolved strain-fields, phase deformation and load transfer in composites, the evolution of stress during temperature (or pressure) fabrication, and the development of strain during reactions (such as reduction, oxidation, or other phase transformations).
Mark Bourke, 505-665-1386, bourke@lanl.gov

FP3 **High Intensity Powder Diffractometer (HIPD)** is designed to study the atomic structure of materials that are available only in polycrystalline or noncrystalline forms.
Robert Von Dreele, 505-667-3630, vondreele@lanl.gov

FP4 **High-Pressure-Preferred Orientation (HIPPO)** instrument is a new high-intensity powder diffractometer for high-pressure and texture measurements.
Kristin Bennett, 505-665-4047, bennett@lanl.gov and Robert VonDreele, 505-667-3630, vondreele@lanl.gov

FP5 **FP5** is used to study the Doppler shift and broadening of low-energy nuclear resonances in materials under extreme conditions and for structural studies using transmission Bragg diffraction.
Vincent Yuan, 505-667-3939, vyuan@lanl.gov

FP6 **Single Crystal Diffractometer (SCD)** has been used to study the structure of organometallic molecules, unique binding of H_2 crystal structure changes at solid-solid-phase transitions, magnetic spin structures, twinned or multiple crystals, and texture.
Yusheng Zhao, 505-667-3886, yzhao@lanl.gov

FP7 **Filter Difference Spectrometer (FDS)** is designed to determine energy transferred to vibrational modes in a sample by measuring the changes in the energies of the scattered neutrons.
Juergen Eckert, 505-665-2374, juergen@lanl.gov

FP9 **Surface Profile Analysis Reflectometer (SPEAR)** is used with an unpolarized neutron beam to study solid/solid, solid/liquid, solid/gas, and liquid/gas interfaces.
Greg Smith, 505-665-2842, gsmith@lanl.gov and Jaroslaw Majewski, 505-667-8840, jarek@lanl.gov

FP10 **Low-Q Diffractometer (LQD)** is designed to study structures with dimensions in the range from 10 to 1000 Å. It measures a broad Q-range in a single experiment without physical changes to the instrument.
Rex Hjelm, 505-665-2372, hjelm@lanl.gov

FP11a **ASTERIX** will provide a polarized neutron beam for studies of magnetic materials, using reflectometry and diffraction, and includes application of high magnetic fields.
Mike Fitzsimmons, 505-665-4045, fitz@lanl.gov

FP12 **FP12** will be used for a fundamental nuclear physics experiment to precisely measure the asymmetry of the emission of gamma rays from the capture of polarized neutrons by protons.
David Bowman, 505-667-7633, bowman@lanl.gov

FP13 **IN500** is a protoype instrument under development employing novel techniques to enhance inelastic cold-neutron spectroscopy at spallation neutron sources.
Margarita Russina, 505-667-8841, russina@lanl.gov
Ferenc Mezei, 505-667-7633, mezei@lanl.gov

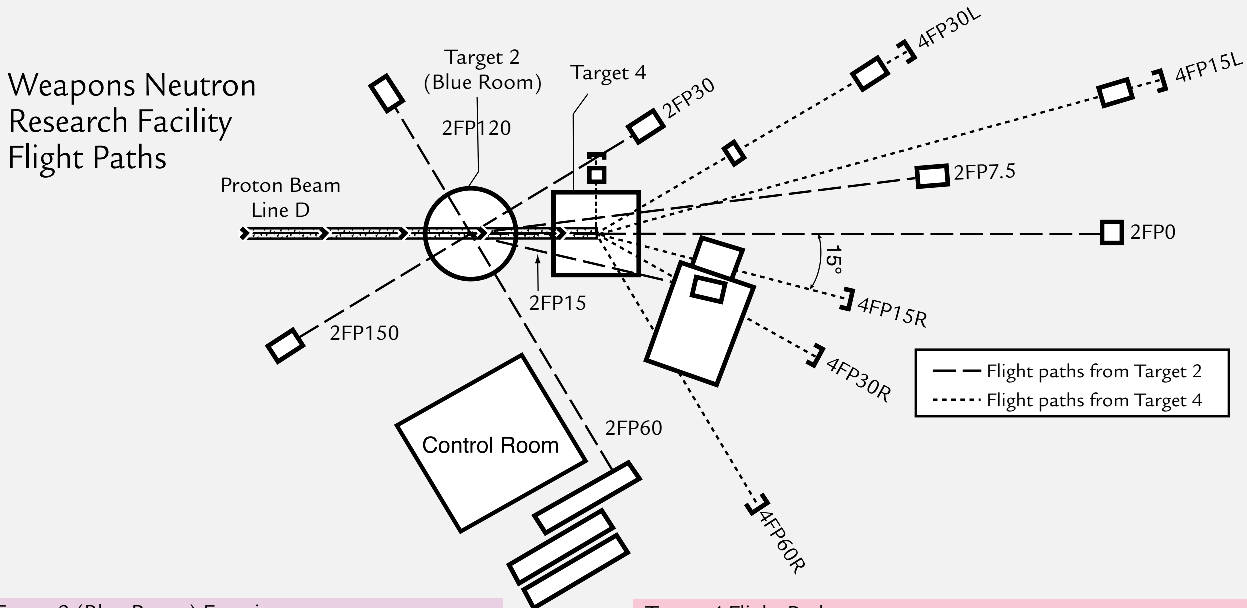
FP14 **Detector for Advanced Neutron Capture Experiments (DANCE)** will be used for the study of neutron capture on radioactive nuclei in support of the stockpile stewardship program and for nuclear astrophysics.
John Ullmann, 505-667-2517, ullmann@lanl.gov

FP15 **Protein Crystallography Station (PCS)** is a single-crystal diffractometer designed for structure determinations of large biological molecules.
Paul Langan, 505-665-8125, langan_paul@lanl.gov
Benno Schoenborn, 505-665-2033, schoenborn@lanl.gov

FP16 **PHAROS** is a high-resolution chopper spectrometer designed for studies of Brillouin scattering, magnetic excitations, phonon densities of state, crystal-field levels, and chemical spectroscopy and measurements of S(Q,ω).
Robert McQueeney, 505-665-0841, mcqueeney@lanl.gov

Target 4 is the most intense high-energy neutron source in the world. Target 4 consists of a "bare" (unmoderated) neutron production target and six FPs with distances ranging from 10 to 90 m and at angles of 15° to 90° with respect to the proton beam. The shape of the neutron spectrum ranges from a hard (high average energy) spectrum at 15° to a softer (lower average energy) spectrum at 90°. The time structure of the proton beam can be modified to produce neutron pulses with different spacings for particular experiments.

Each FP has a name that tells the source of the FP and its direction with respect to the proton beam. For example, 4FP15R is an FP that starts at Target 4 (thus "4FP") and is 15° to the right (15R) of the incoming proton beam.



Target 2 (Blue Room) Experiments

In **neutron resonance spectroscopy**, the PSR beam is used to produce an intense single pulse of neutrons for measuring the temperature and particle velocities of dynamic systems at different times during their evolution. The temperature is obtained by measuring the Doppler broadening of low-energy neutron resonances.

Single pulses from the PSR beam are used in **shock diagnostics** to study the shock induced by the incident beam on a liquid mercury target for the Spallation Neutron Source (SNS).

A **UCN source** using solid hydrogen is being developed.

A program is under way to study the **enhancement of superconductivity in high-temperature superconductors** caused by the introduction of defects from proton-induced fission reactions of the heavy element constituents of the superconductor.

Target 4 Flight Paths

FP90L	This FP is used to measure neutron-proton capture cross-sections important for understanding Big Bang nucleosynthesis.
FP30L	This FP has two experimental stations. The first station is at approximately 20 m from the production target and is where accelerated neutron testing of semiconductors by industrial researchers can be done. The second station is at a distance of 40 m and was most recently used for high-energy neutron radiography.
FP15L	This FP provides the highest neutron energy resolution. At present, the approximately 90-m-long FP is being used for dosimetry, neutron transport, and (n,2p) experiments.
FP15R	The (n,d) scattering experiment, which uses a liquid hydrogen target, is located on this approximately 18-m-long FP.
FP30R	Most recently, experiments on this approximately 20-m-long FP studied neutron-induced reactions for nuclear-level-density studies.
FP60R	The GEANIE spectrometer consists of approximately 26 Compton-suppressed, high-resolution germanium gamma-ray detectors and is located on this approximately 20-m-long FP. The GEANIE instrument is used to address issues of nuclear structure, spectroscopy, and cross-section measurements for both stockpile stewardship and basic science.

Isotope Production Facility

To ensure that U.S. doctors and researchers have a steady supply of medical isotopes, DOE/NE is funding the construction of a new IPF to replace the existing facility at LANSCE. Construction of the new $16.5 million IPF began in February 2000, and the project is expected to be completed in June 2002.

Combining the new IPF's output with similar isotope production capabilities at Brookhaven National Laboratory (BNL) will ensure doctors and researchers an adequate, year-round supply of accelerator-produced medical isotopes. Medical isotopes are needed to perform 36,000 diagnostic procedures daily and 50,000 therapies annually, along with 100 million lab tests annually. The DOE Office of Isotopes for Medicine and Sciences estimates the annual value of these procedures to the medical industry at between $7 billion and $10 billion. The Chemistry Division has produced some of these medical isotopes, such as strontium-82 and germanium-68, at LANSCE for more than 20 years. Using a portion (~100 MeV) of the 800-MeV LANSCE proton beam, the new IPF at LANSCE will irradiate a wide range of materials underground, including rubidium chloride, gallium, and other targets. Targets will then be shipped to the Chemistry Division for processing.

Proton Radiography

In Area C, scientists use H^- beam from the linac as a radiographic probe for creating multiple high-spatial-resolution images of imploding or exploding objects with submicrosecond time resolution. Protons interact through strong electromagnetic forces allowing the simultaneous measurement of different material properties, such as material density and composition distributions.

Protons have several properties that are advantageous for these types of experiments, including

- high penetrating power,
- high detection efficiency,
- very little scattered background, and
- inherent multi-pulse capability.

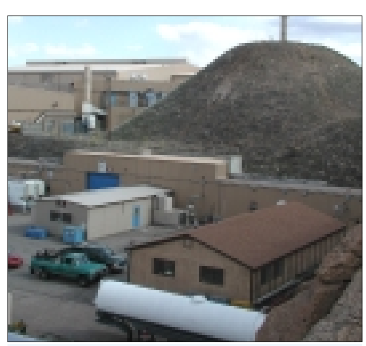
In addition, large distances are possible from the test object and the containment vessel for the incoming and transmitted beams, therefore reducing the background calculation from scattered particles.

Los Alamos scientists are developing PRAD as a tool for studying stockpile stewardship problems. They have developed magnetic optics; fast, integrating, large-area detectors; and containment vessels both to solve important weapons physics problems and to lay the groundwork for an AHF capability.

Ultra-Cold Neutrons

In Area B, scientists are planning to direct the H^- beam onto a small tungsten target to produce neutrons. These neutrons will be moderated to very low energies by layers of polyethylene at liquid nitrogen temperature (77 K) and liquid helium temperature (5 K) surrounded by solid deuterium to produce UCNs. UCNs have sufficiently low energy that they cannot penetrate materials; thus they undergo total reflection at all angles. As a result, the UCNs produced by this target/moderator configuration will be "trapped" in "bottles" or directed along guide tubes. While developing this capability over the last few years, the team has achieved the predicted number of UCNs by refining the experimental apparatus. In 2000, this team achieved a new world's record for the density of UCNs stored in a bottle: 100 UCNs per cubic centimeter. With this achievement, the team is proposing a full-scale UCN source to be installed at LANSCE. The predicted steady-state UCN density of 300 UCNs/cm^3 is approximately eight times the highest existing UCN production source capability of 41 UCNs/cm^3 measured at the Institute Laue-Langevin (ILL) research reactor in France. Design and initial stages of construction of the full-scale source and experiments are now in progress. This new source will allow the team to measure neutron decay asymmetry with previously unattainable precision.

↑ *The nearly completed Isotope Production Facility.*



↑ *Experimental Area C.*

↑ *Proton radiography beam line.*

Programs and Projects

Short-Pulse Spallation Source Enhancement Project

The goal of this collaborative project, which is funded by DOE/DP and DOE/SC, is to significantly upgrade LANSCE capabilities by increasing the neutron source intensity and by constructing additional neutron scattering spectrometers at the Lujan Center.

DOE/DP funds the accelerator upgrade to provide 200 mA of H^- beam current to the Lujan Center target. The major components of the accelerator upgrades are a new H^- ion source and injector system, an upgraded radio-frequency (rf) bunching system, a new inductor and additional multipole magnets in the PSR, and new magnets in the Lujan Center beam line. These improvements will result in greater neutron flux for experiments at the Lujan Center.

DOE/SC funds the construction of three advanced neutron-scattering instruments at the Lujan Center. These instruments are being built by teams of scientists from academia, industry, and federal laboratories and will be used for research by both the teams' members and general users. Two instruments, SMARTS and HIPPO, are funded by OBES and are under construction with commissioning in the summer of 2001. The DOE Office of Biological and Environmental Research (OBER) is funding another instrument for protein crystallography. This instrument was built by the Bioscience Division and accepted its first neutron beam in December 2000.

Advanced Hydrotest Facility

The AHF is an important future capability of the DOE/DP Stockpile Stewardship Program. The AHF will use pulses of protons traveling at very near the speed of light to penetrate dense, fast-moving objects at many angles simultaneously. The protons will thereby provide three-dimensional high-resolution radiographic motion pictures. Those images will give Los Alamos and Lawrence Livermore National Laboratory (LLNL) scientists critical information necessary to assess the safety, performance, and reliability of our aging nuclear weapons stockpile.

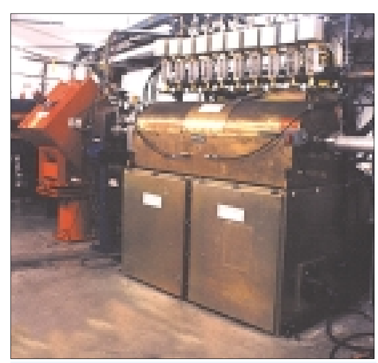
The AHF Project at LANL has been designated by DOE/DP as the lead organization for planning, constructing, and commissioning the AHF as a national user facility for providing unique data crucial to nuclear weapons certification in the coming decades. During the past two years, the LANSCE project team, in collaboration with LLNL, industry, and university partners, developed options and performed design trade-off studies for a facility that would meet all future requirements of the weapons community. In 2001, the project began engineering development activities of key system components—a fast-rise anharmonic kicker-modulator, large field-of-view superconducting quadrupole lenses, and the composite inner vessel. The project is completing preconceptual design studies in anticipation of a Justification of Mission Need (Critical Decision 0) by DOE/DP.

Advanced Accelerator Applications and Tritium Mission

In the fall of 2000, LANL was named the lead laboratory for a new program to advance the use of accelerators for transmutation and other nuclear-science applications. The Advanced Accelerator Applications (AAA) project is a multilaboratory and industry partnership. The program combines technology development and design efforts from the former Accelerator Production of Tritium (APT) and Accelerator Transmutation of Waste programs into a new effort with a broader purpose. Participating laboratories include BNL, Argonne National Labortory (ANL), LANL, Sandia National Laboratories (SNL), and the Savannah River Site (SRS). Industry partners include Burns and Roe Enterprises, Inc., and General Atomics. The project headquarters are at Los Alamos. The program already involves university

↑ *A proton radiography experiment.*

↑ *Researchers collaborate on PRAD experiment.*



↑ *Proton Storage Ring.*

collaborations, a component that is expected to grow significantly as the program develops. The goals of AAA over the next decade are threefold: (1) to demonstrate the proof-of-performance and practicality of transmutation (the nuclear transformation of long-lived radioactive materials into short-lived or nonradioactive materials) in terms of meaningful impact on nuclear materials and waste management; (2) to define and execute activities designed to sustain the country's nuclear-science and engineering infrastructure; and (3) to continue technology development and demonstration applicable to a backup, accelerator-based tritium production capability should national security dictate a need for this capability. To meet these goals, the consortium plans to construct an accelerator-driven test facility, which will also function as a national nuclear-science and engineering user facility.

Accelerator Production of Tritium

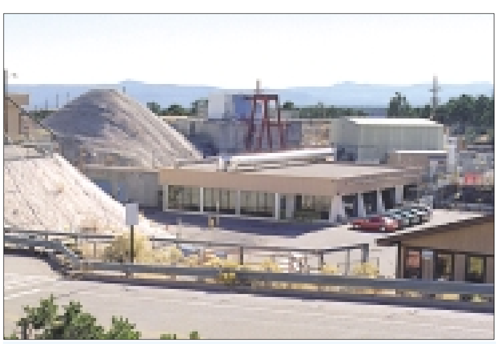
From 1996 until 2000, the APT program conducted a major irradiation effort at LANSCE's Area A experimental facility using the direct 800-MeV H^+ beam at 1 mA on a tungsten spallation target. The power, length, and scope of this irradiation is unprecedented. Over 5,000 mechanical test samples, as well as experiments on corrosion, gas and water contamination, tritium production, and decay heat, were placed within the resulting proton and secondary particle flux. In 1999 and 2000, the actual irradiation, disassembly of the apparatus, and analysis of the specimens were completed. Containers of irradiated samples were first shipped to the hot cells at NMT Division's Chemistry/Metallurgy Research Building for processing and then distributed to researchers at LANL, Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory, SNS, and a number of universities. This work has resulted in the first *Materials Handbook and Structural Design Criteria* for high-power, intermediate-energy accelerator applications. These documents have already become important resources for the spallation source industry and help lay the foundation for future design work for Accelerator Transmutation of Waste and advanced neutron spallation sources.

Although analysis of samples has been ongoing for several years, the testing of aluminum, tungsten, and a number of welds between dissimilar materials was completed during 1999-2000. In addition, an important and highly successful test of the decontamination of the water system serving one of the experimental inserts was performed with the NITROX process typically used for reactors. Additional experiments in dosimetry and energy deposition were also carried out at the WNR facility and in Line B. LANSCE facilities supported the work sponsored by the APT program and will continue to support follow-up work under the sponsorship of the AAA program.

Spallation Neutron Source

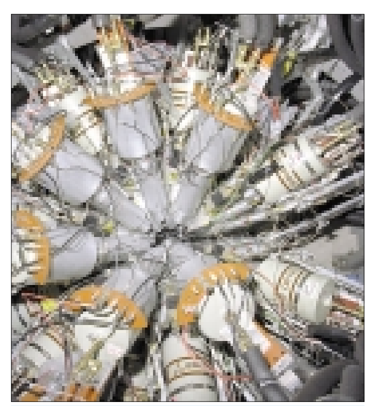
The Spallation Neutron Source (SNS) project is a major DOE initiative designed to develop the world's most intense pulsed neutron source for neutron-scattering experiments and material-science studies. The SNS, which is under construction at ORNL, will consist of a high-intensity H^- ion source, a 1-GeV linear accelerator, a pulse-stacking accumulator ring, a neutron production target, a set of neutron-scattering instruments, and the conventional facilities required to house the systems. Neutrons will be produced by injecting a 1-GeV energy, 1.4-MW average power, pulsed proton beam into a mercury target.

The design and construction of the SNS is being carried out by a collaboration of six DOE laboratories: ORNL, LANL, ANL, BNL, Lawrence Berkeley National Laboratory, and Jefferson National Laboratory. LANL's main responsibilities are to (1) design, construct, deliver, and help install and commission a normal-conducting linac, which consists of 87-MeV-drift-tube and 186-MeV-coupled-cavity accelerating systems; (2) provide beam physics analyses for the entire linac; (3) provide more than 100 MW of radio-frequency power for the entire linac; and (4) develop the experimental physics and industrial control system for the linac.



↑ *The Weapons Neutron Research Facility.*

↑ *Experimenters in WNR Blue Room.*



↑ *GEANIE instrument array.*

Advanced Concepts and Applications

LANSCE addresses important national problems by performing research and development on high-power microwave sources and advanced pulsed-power systems for both defense and advanced accelerator applications. Other research areas include the interaction of microwave radiation and matter; microwave-driven chemistry; and development of advanced electrodynamic systems, including the advanced free-electron laser and the high-brightness, subpicosecond bunch-electron accelerator. Theoretical research is conducted on issues involving intense-electron-beam physics, including coherent synchrotron radiation and emittance growth mechanisms in high-current linear induction accelerators. By tackling many difficult problems for DOE and the Department of Defense (DoD), other federal agencies, and industry, our research stays at the scientific forefront that in turn advances the state of the art of the accelerator technology needed for next-generation accelerators.

Laboratory Directed Research and Development Projects

The LDRD program supports internally proposed, innovative research and development work that extends the Laboratory's science and technology capabilities. The selection process is highly competitive, with a comprehensive review by peers or Laboratory managers and selection based on innovation and scientific merit in a mission context. The LDRD program has two major components: directed research (DR) and exploratory research (ER).

The DR component provides funds to make larger strategic investments in research and development projects, usually multidisciplinary in nature with multiorganization participation, with the work being motivated by the Laboratory's Strategic Plan. The ER component provides funds to conduct staff-initiated research and development that is highly innovative in scope and often at the forefront of their disciplines but in areas of science and technology that underpin our core mission. LANSCE has many projects that owe much of their success to LDRD support. Examples of current LANSCE projects are

- instrument development (ASTERIX and IN500);
- development of high-performance cold neutron spectroscopy at LANSCE;
- high-power microwave science and technology;
- synthesis and characterization of superhard material;
- measurement of (n,γ) cross sections for unstable nuclei of interest to s-process nucleosynthesis; and
- test of Big-Bang nucleosynthesis model prediction by measurement of the $n+{}^{1}H \rightarrow {}^{2}H+\gamma$ cross section.

Sponsors

LANSCE addresses important issues for each of the major DOE stakeholders—DP in the NNSA, SC, and NE.

Issues for Stockpile Stewardship

The Stockpile Stewardship Program at LANSCE supports the operation of the 800-MeV proton accelerator and its neutron-generating targets. Defense research takes advantage of a wide range of LANSCE capabilities to provide the DOE/NNSA/DP community with information critical to the national stockpile stewardship mission: maintaining safe, secure, and reliable nuclear deterrence without nuclear testing. Among the capabilities being exploited at LANSCE are neutron scattering, proton and neutron radiography, neutron resonance spectroscopy, and neutron-induced nuclear-reaction measurements.

The stockpile stewardship research program at LANSCE has been designed to give the traditional weapons design and engineering community capabilities to study issues related to the stockpile. LANSCE researchers provide fundamental data to inform and guide the development of full-fidelity physics modeling of nuclear explosions. This modeling is being implemented on a new generation of supercomputers—the fastest in the world—at the DP laboratories as part of the Accelerated Strategic Computing Initiative (ASCI). In addition, LANSCE research is contributing to the development of advanced manufacturing processes that will be important for stockpile refurbishment activities in the future. Current stockpile stewardship research projects, which

↑ *GEANIE instrument set-up.*

↑ *Manuel Lujan Jr. Neutron Scattering Center.*

↑ *Lujan Center Experimental Research Area 2.*

have enhanced the visibility of LANSCE in the nuclear weapons community, are as follows (page numbers of related articles in this report are included):

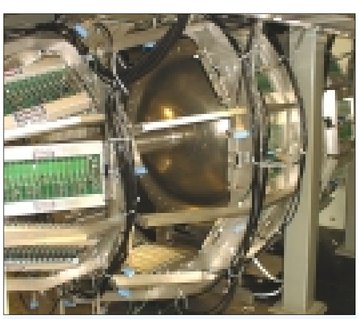
Title	Page
Combining Deuteration with Small-Angle Neutron Scattering to Study the Effects of Aging in Estane	26
Inelastic Neutron Scattering and the Nature of Vibrational Softening in Uranium	50
Residual Strains in a Pigma-Welded Beryllium Ring	54
Strain Response in Beryllium	56
AccelView—An Innovative Tool Designed to Simulate, Visualize, and Animate Accelerator Beam Lines	90
H^- Ion Source Development at LANSCE	94
Advances in Nuclear Physics Research with GEANIE at the Weapons Neutron Research Facility	106
Purified Plutonium Reduces Background Interference in Nuclear Cross-Section Measurements	112
Neutron Capture Measurements on Unstable Nuclei at LANSCE	116
Accomplishments in Neutron Resonance Spectroscopy	118
High-Energy Neutron Radiography as a Tool for Stockpile Surveillance	134
Proton Radiography Experiments at LANSCE	138
Short-Pulse Spallation Source Enhancement Project	142
Accelerator Systems for the Advanced Hydrotest Facility	150
DANCE—A Detector for Advanced Neutron Capture Experiments	178
FIGARO—A Fast Neutron-Induced Gamma-Ray Observer	182

National User Facilities for Neutron Scattering

The DOE/SC/OBES has a major responsibility for planning, designing, constructing, and operating major scientific user facilities. These user facilities, including the Lujan Center and SNS, offer world-class capabilities for basic and applied research to researchers from universities, national laboratories, and industry. Acquiring new knowledge that cannot be obtained by other means enables the determination of behavior of matter. The experiments at OBES user facilities embrace the full range of scientific and technological endeavors, including chemistry, physics, materials science, geology, biology, and engineering science.

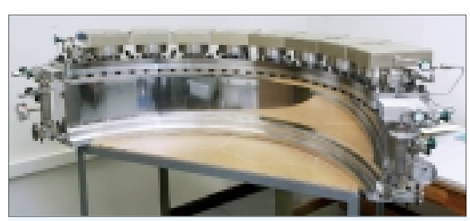
The Lujan Center contributes to this objective through the development of world-class spectrometers and in-house and external forefront research. LANSCE supports linac development for the SNS. Current activities that support these SC goals include the following (page numbers of related articles in this report are included):

Title	Page
Diffraction Studies of Twinning in Pure Zirconium	22
How Molecules are Adsorbed in Zeolite Catalysts	30
Neutron Scattering Identifies Asymmetric Magnetization Reversal in Exchange-Biased Heterostructures	34
Incorporation of Lung Surfactant Specific Protein SP-B into Lipid Monolayers	36
Phonons and High-Temperature Superconductivity	38
Qualitative Measurements in High-Pressure Olivines—Understanding Seismic Anistropy in Earth's Upper Mantle and Transition Zones	42
Neutron Reflectometry—A Tool for Studying Diffusion in Plastic	46
High-Pressure Neutron Diffraction Study of Carbon Black	58
Combined Rietveld- and Stereochemical-Restraint Refinement with High-Resolution Powder Diffraction Data Offers a New Approach for Obtaining Protein-Drug Structures	60
Operational Results of the Spallation Neutron Source Polyphase Converter-Modulator for the 140-kV Klystron Radio-Frequency System	82
New Tools to Transport and Archive Data in EPICS	86
Chopper Control	96
Short-Pulse Spallation Source Enhancement Project	142
SMARTS—Providing New Capabilities in Materials Research	156
HIPPO—A New High-Intensity Neutron Diffractometer for Characterizing Bulk Materials	160



↑ *Inside the new HIPPO instrument.*

↑ *Outside view of the new SMARTS instrument.*



↑ *PCS array detector.*

Title	Page
Upgrade of the Neutron Powder Diffractometer	176
Designing Neutron Scattering and Optics Instruments with a Versatile Monte Carlo Tool Developed at LANSCE	186
Coupled Moderators at the Manuel Lujan Jr. Neutron Scattering Center	190
Upgrades to Existing Beam-Line Safety Systems	192

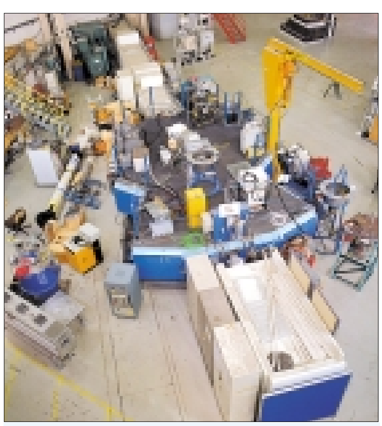
Nuclear Physics Research

The mission of the nuclear physics program, within the DOE Office of High Energy and Nuclear Physics (OHENP), is to promote nuclear physics research through the development and support of basic-research scientists and facilities. Nuclear-physics research seeks to understand the fundamental forces and particles of nature as manifested in nuclear matter. DOE provides approximately 85% of U.S. nuclear-physics research funding, much of which is directed toward the development, construction, and operation of large state-of-the-art accelerator facilities and detectors at national laboratories. These facilities are used by researchers from laboratories and universities worldwide (page numbers of related articles in this report are included):

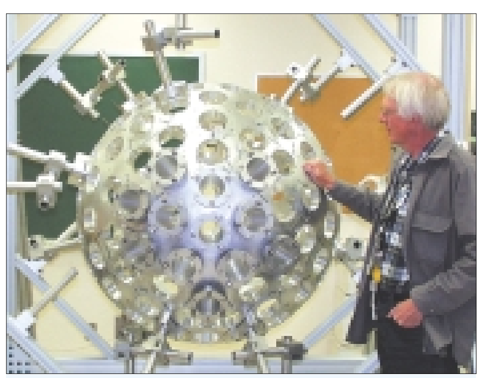
Title	Page
Ultra-Cold Neutron Physics at LANSCE	102
Advances in Nuclear Physics Research with GEANIE at the Weapons Neutron Research Facility	106
Development of a New Experiment to Search for the Electric Dipole Moment of the Neutron	110
Neutron Capture Measurements on Unstable Nuclei at LANSCE	116
Measurement of the Beta Asymmetry with Ultra-Cold Neutrons	120
Level-Density Information for Nuclear Reaction Models	122
Nuclear Cross Sections for Planetology	126
Few Nucleon Physics at the Weapons Neutron Research Facility	130
DANCE—A Detector for Advanced Neutron Capture Experiments	178
FIGARO—A Fast Neutron-Induced Gamma-Ray Observer	182

Isotope Production for Medicine and Science Programs

The DOE national laboratories offer unique isotope production and separation facilities and processes. At LANSCE, the IPF complements the other DOE isotope production activities through the production of exotic isotopes that cannot be produced at the other facilities. Three major products that will be produced are germanium-68, a calibration source for positron emission tomography (PET) scanners; strontium-82 (the parent of rubidium-82) used in cardiac PET imaging; and sodium-22, a positron emitter used in various applications. The new 100-MeV facility described previously will produce these same isotopes, but with greater efficiency. This new facility will advance DOE's objective to be a reliable domestic source of essential medical and research isotopes (see page 146).



↑ *Neutron Powder Diffractometer.*



↑ *DANCE support sphere.*

↑ *Scientist adjusts calibration on SCD.*